NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

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USE OF PRESTRESSED CONCRETE ELEMENTS IN WATER SUPPLY SYSTEMS

RESULTING GAINS IN FOREIGN EXCHANGE AND INDUSTRIAL DEVELOPMENT

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INTRODUCTION

1. The use of prestressed concrete for water storage reservoirs and water aqueducts has started in the United States since the early days of use of prestressed concrete.

2. As the knowledge of the design and the available materials improved, prestressed concrete tanks and pipes have become competitive and are used very extensively.

3. Whereas at the beginning such applications were mostly in highly industrialized countries, they are now used more and more in developing countries as they present, in addition to savings in cost, the advantage in saving in foreign exchange and are helping in the industrial development by the formation of local industries that can easily be adapted for other uses in the construction field.

THEORETICAL ASPECTS

4. Both prestressed pipes and tanks are structurally cylindrical shells. Since the main load they have to resist is internal pressure, prestressing in both cases consists of a circumferential wrapping of wires (or cables) that pre-compresses the concrete cylindrical shell whilst empty. Thus, when the pipes carry water under pressure or the tank is full, the concrete core instead of being under tension is decompressed. The design in both instances has to supply enough prestressing so as to have the concrete decompressed to zero stresses at maximum loading after the creep of steel and shrinkage of concrete have taken place.

5. Both prestressed pipes and prestressed tanks have a concrete core precompressed by wrapping high tensile wire around it and then an outside protective concrete or mortar coating to protect the wire from corrosion.

PRESTRESSED CONCRETE PIPES

6. The economic advantage gained with prestressed concrete pipes is based on the fact that the internal pressure of the water is taken by high tensile wire instead of mild or medium grade steel. High tensile wire is now produced by the industry at only twice the cost of regular steel whilst it has a useful tensile strength six to eight times higher than the strength of regular steel. The cost advantage, however, obtained in favour of high tensile wire, is reduced by the need of using high tensile wire in combination with concrete (a concrete core to be compressed by the high tensile wire and an outside concrete or mortar protective coating), while regular steel pipe requires only protection from corrosion. However, experience has shown that even in countries with high labour rates, the cost of the concrete required is less than the saving in cost of steel gained through the use of high tensile wire.

7. This cost advantage is particularly high for large diameter pipes. For diameters of less than 60 cms. the cost of producing the concrete pipes, that will be prestressed with high tensile wire, increases to the extent that, depending on local conditions of costs of materials, it might upset the saving and make the steel pipe more economical. For the above reasons, prestressed pipes are particularly advantageous for large diameters, preferably exceeding 1 m. where the cost differential is much larger.

8. For countries importing their steel requirements from abroad, prestressed concrete in substitution to steel pipes becomes even more important, as the cost of steel is equivalent to the need of expenditure in foreign exchange whilst the cost of concrete (labour and the biggest part of the cost of concrete materials) is in local currency.

9. The manufacture of prestressed concrete pipes can be done near the site of their actual use, thus eliminating the cost of transportation.

10. A prestressed concrete pipe manufacturing plant can easily be operated by local personnel and thus assist in the industrial development of the country. After the completion of the manufacture of the pipes required, the plant can be used for the manufacture of additional concrete pipes or other precast prestressed concrete elements and thus assist in the needs of the building industry of the area.

11. Until now, in most cases the manufacture of prestressed concrete pipes was entrusted to one of a few specialized international firms with experience in this field.

12. The writer was instrumental in having prestressed concrete pipes manufactured by a local firm for the Athens aqueduct.(1)

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(1) Doanides, P. J.: Prestressed pressure pipe lines for the Athens Aqueduct. "Civil Engineering" of the American Society of Civil Engineers, p. 653-657 (1958).

THE PRESTRESSED CONCRETE PIPE MANUFACTURING PLANT FOR THE EXTENSION OF THE WATER SUPPLY OF TEHRAN

13. Another very interesting case successfully tried out in Iran, is the Pipe Manufacturing Plant for the prestressed pipes required for the water supply of Greater Tehran.

14. The Tehran Water Board, instead of entrusting the manufacture of prestressed pipes to a foreign firm, decided to ask internationally for tenders for the supply and erection of a prestressed concrete pipe manufacturing plant. This plant, now completed, is operated departmentally by the Tehran Water Board who use their own engineers and local labour.

15. This plant is required for the manufacture of approximately 30,000 l.m. of 2m inside diameter low pressure pipes to carry the water from the newly built Karaje Dam to the water treatment plant located just West of Tehran, and approximately 28,000 l.m. of high pressure pipes with diameters of 1.85, 1.70, 1.40 and 1.35 meters required as water distribution mains from the treatment plant to the city.

16. The savings obtained from the substitution of steel with prestressed concrete have been estimated as follows:

a. Cost savings including all materials, labour and full depreciation of all equipment 18%

b. Savings in foreign exchange including again all materials imported and produced locally, cost of labour and supervision, including foreign experts and full depreciation of all imported and locally manufactured equipment 44%

17. The plant is at present producing 600 tons of pipes per day and employs a total number of 350 men: This number includes 16 graduate Iranian Engineers and approximately 60 operators of equipment, welders and other skilled workers, the remainders being unskilled labourers.

18. The plant has been so planned and designed as to be able to produce the pipes that will be required for the extension of the water supply of Greater Tehran. It can also be used with small changes for the manufacture of sewer pipes and other precast prestressed elements.

PRESTRESSED RESERVOIRS

19. Prestressed concrete is also used for water storage reservoirs.

20. In view of the internal water pressure, the most economical form for water reservoirs is the cylinder. The cylindrical wall shell is subject to tensile stresses which justify the use of steel plates as material. With prestressed concrete, a concrete cylindrical wall shell is precompressed by high tensile wire wound under tension around the shell or applied in the form of circumferential prestressing cables that apply a compressive load to the concrete cylindrical shell. Again, like in the case of prestressed pipes, when the tank is filled with water, the concrete is decompressed rather than placed under tension and the water pressure is resisted by this combined decompression of the concrete and a slight increase in tension of the prestressing wire.

21. Water storage reservoirs are also built with regular reinforced concrete, however, in view of the fact that concrete resists very poorly tensile stresses, reinforced concrete non prestressed reservoirs require considerably larger quantities of both concrete, as well as reinforcing steel.

22. The special equipment required for the construction of prestressed circular reservoirs is relatively inexpensive and fairly simple to operate. It would therefore be most desirable to see this method of construction more widely used in countries under development, as besides savings in costs, it reduces the need in foreign exchange and increases the use of local materials and local labour.

23. It is also possible to substitute the cast in situ cylindrical concrete wall with precast concrete panels and thus reduce the requirements in forms. This is particularly desirable for countries where timber or steel forms are to be imported from abroad.

24. An interesting example is the two precast prestressed water storage reservoirs built in 1954 in Sasolburg, South Africa.[2] [3] These tanks have each a capacity of 7,500,000 imperial gallons (35,000 cu. ms) and a diameter of 280 ft. (85.50 mts.) - See figure

CONCLUSION

25. The progress of the technology of prestressed concrete makes possible the use of this composite material in the manufacture of large diameter pressure pipes and water reservoirs, in countries under development.

26. The use of prestressed concrete is very desirable as it not only reduces the cost of the project, but in addition, assists by saving in foreign exchange requirements and by encouraging the formation of local building industries.

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(2) Doanides, P. J.: Some Notes on Precast Prestressed Tanks. "Transactions of the South African Institution of Civil Engineers". p. 207-238 (1955).

(3) Doanides, P. J.: Big prestressed concrete tanks built with precast panels. "Civil Engineering" - American Society of Civil Engineers, p. 562-564 (1955).

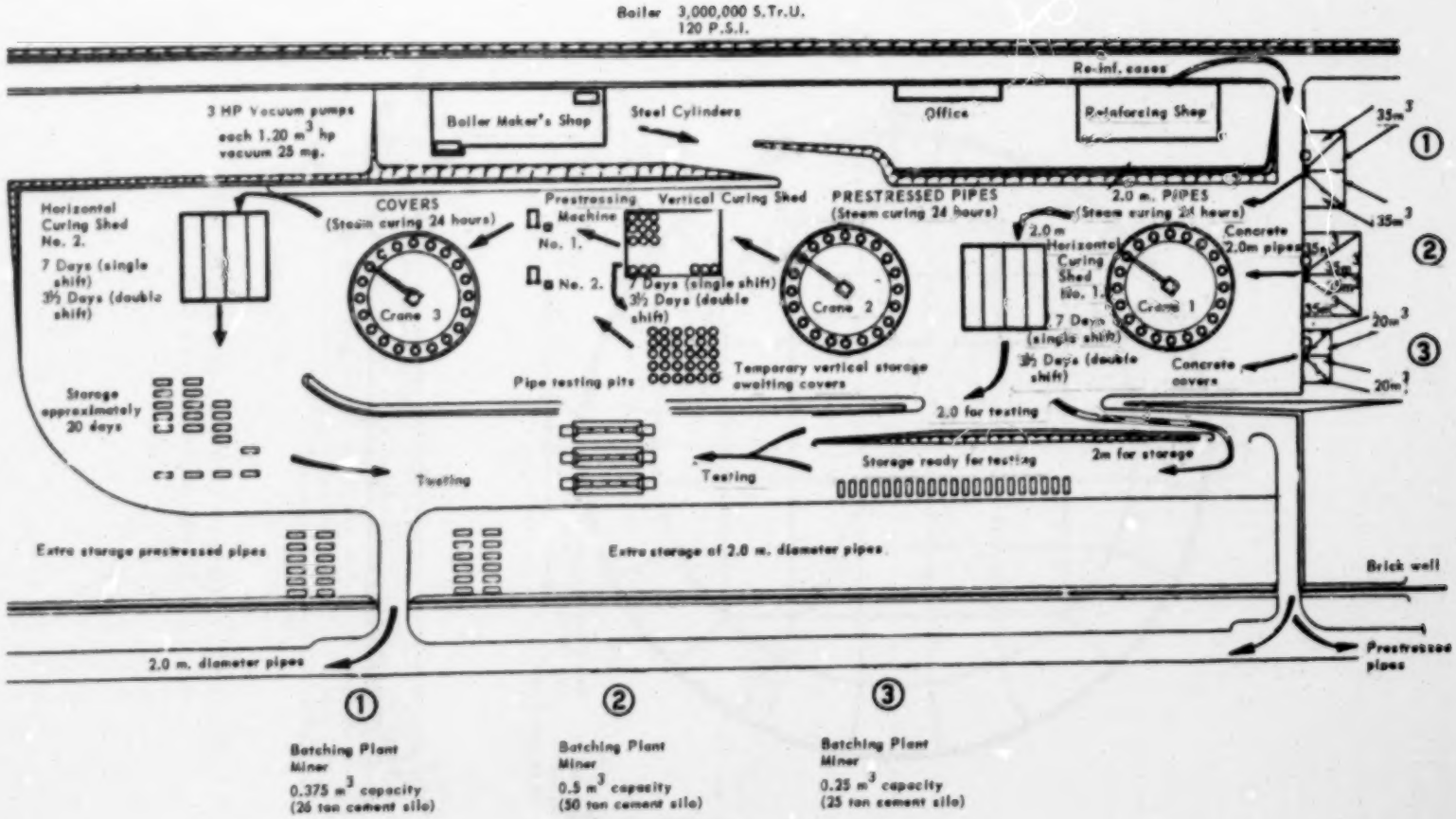

Figure 1 - Casting Yard Layout, Tehran

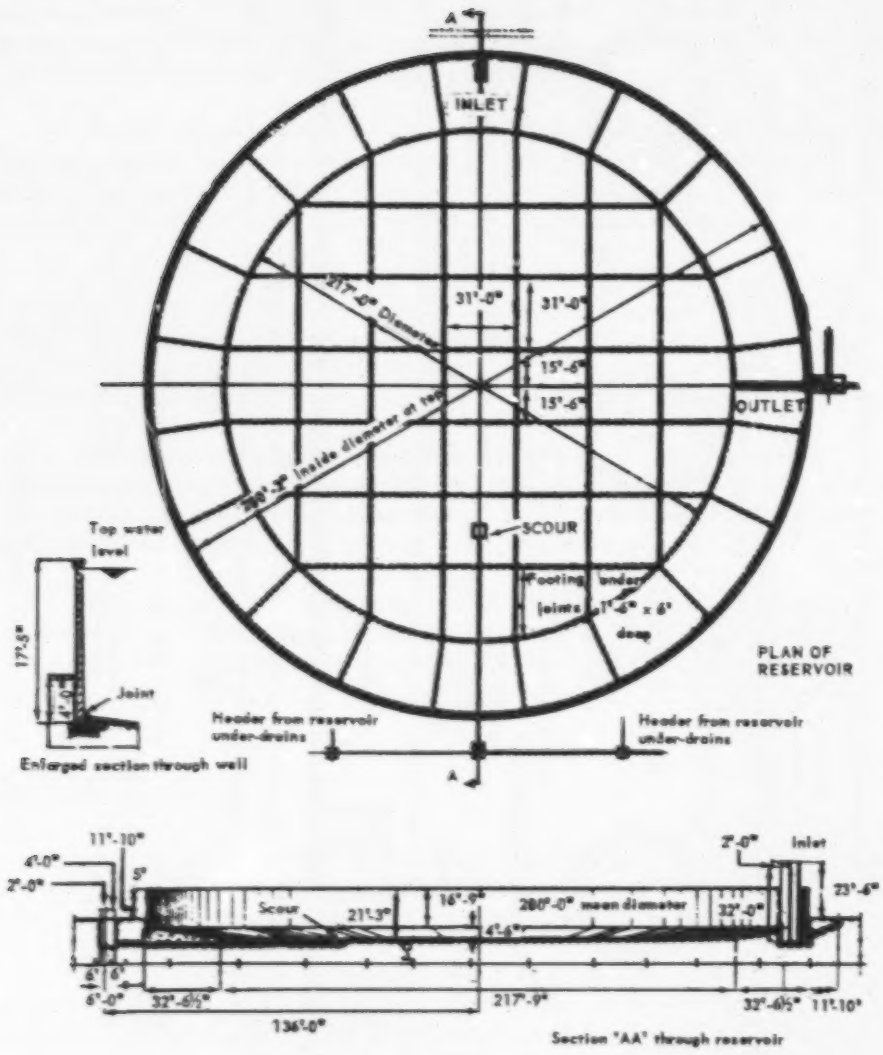

Figure 2 - Plan and elevation of 9 1/2 million U. S. gallon reservoirs at Sasol

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